



# **Commercial Crew Program Status to NAC**

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# Agenda



- **Program Status**
- **Summary of Recent Flight Tests**
  - Boeing Pad Abort Test
  - Boeing Orbital Flight Test
  - SpaceX In-Flight Abort Test
- **Upcoming Flight Test Status**
  - SpaceX Demonstration Mission-2 Status
  - Boeing Next Flight Test Status
- **Contract and Cost Performance**
- **Recent Developments**
- **Summary**



# Program Status

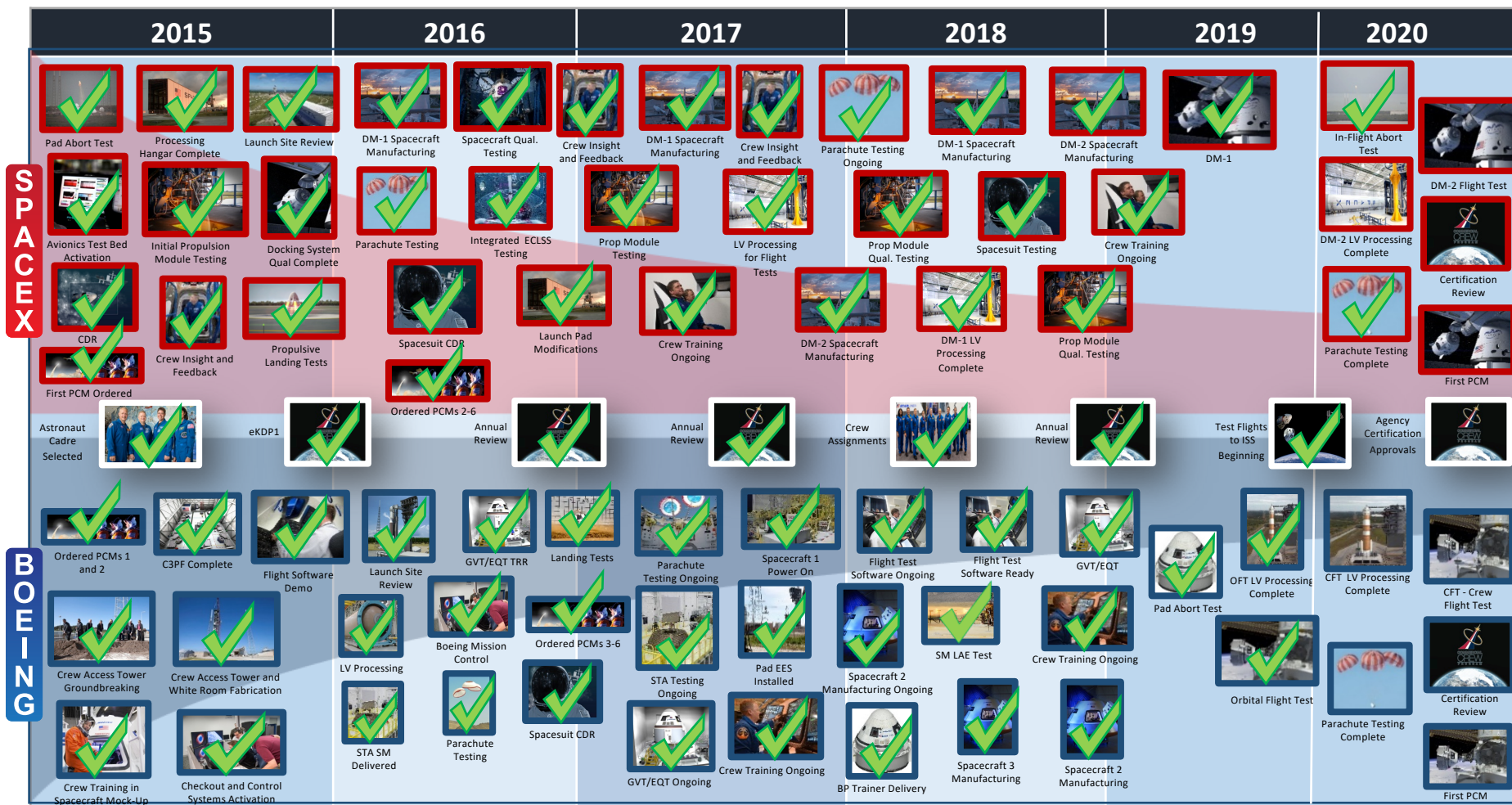


**The Commercial Crew Program (CCP) has made significant progress since the last NAC status briefing.**

- **Both providers have completed uncrewed flight tests and abort tests.**
- **Space hardware manufacturing, testing and qualification continue. Burn down of certification products also continues.**
- **Official Launch Dates for the upcoming crewed missions:**
  - SpaceX Demonstration Mission-2: May 27, 2020
  - Boeing Orbital Flight Test-2 (OFT-2): Under Review
- **Coronavirus restrictions have presented new challenges. But, CCP has been determined to be “mission critical” and work is proceeding.**



# Timeline to the International Space Station



\* Remaining Boeing milestones are under review.

Last Updated  
Apr 2020



# Boeing Pad Abort Test

- **Pad Abort Test completed on November 4**
- **Overall Test Observations**
  - Vehicle trajectory consistent with pre-test predictions
  - Separation performance nominal
  - Air bag deployment/function nominal
- **Parachute Deployment Anomaly**
  - Root cause identified
  - Process enhancements implemented
  - Subsequent Orbital Flight Test was a full-system test with a nominal landing



- **Mission Overview:**

- Launch site: Cape Canaveral SLC-41
- Launch date: 20 December 2019
- Landing site: White Sands Missile Range
- Landing date: 22 December 2019
- Mission duration: 2 days, 1 hour



- **2 Seats / No crewmembers**

- Seat 1: Instrumented Anthropomorphic Test Device
- Seat 2: Empty

- **Cargo Accommodations:**

- Passive cargo only (571 lbs)
- No powered payloads





# OFT Outcomes



**Multiple post-flight activities have been accomplished or are in work as a result of the issues observed during the flight.**

- **NASA and Boeing formed a joint Investigation Review Team (IRT) to review three primary anomalies experienced during the mission: two software coding errors and unanticipated loss of space-to-ground communication capability. Root causes were determined for the anomalies and over 60 corrective actions identified.**
- **Separate from the IRT, NASA reviewed its role in the flight test and identified several areas where the agency can improve its level of participation and involvement into company's processes.**
- **In addition, Boeing and CCP completed an extensive "Lessons Learned" assessment and identified many items to enhance future flights.**
- **NASA will perform an Organizational Safety Assessment of the workplace culture of Boeing's CCP team.**
- **NASA designated OFT as a High Visibility Close Call. A Mishap Panel has been initiated and work is underway.**



- **SpaceX executed the In-Flight Abort Test from Kennedy Space Center Pad 39A on January 19, 2020**
  - Escape initiated at ~84s into flight
  - Stage extension, trunk, and Dragon Capsule incorporated SuperDraco propulsion system updates since static fire anomaly
- **Data and video indicate a fully successful test, which employed all relevant logic between Dragon and F9**
- **Test demonstrated separation and escape from the launch vehicle, a controlled SuperDraco burn, Draco reorientation and stability control, Mark 3 chute deployments and successful splashdown**

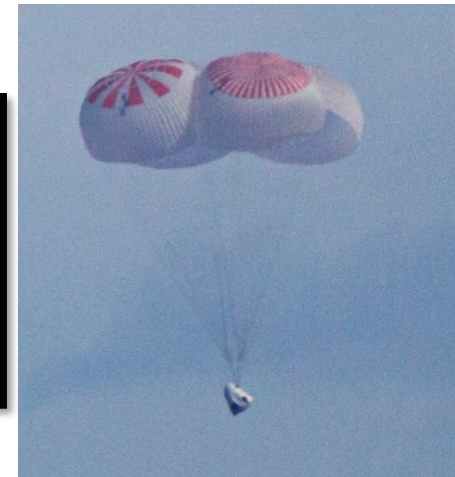
Launch



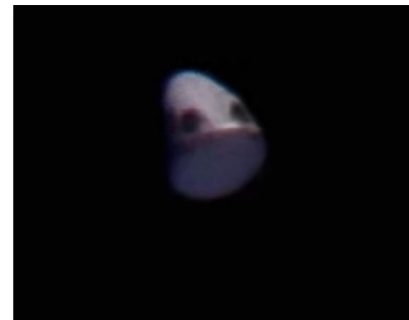
SuperDraco Escape Initiation



Under Main Chutes

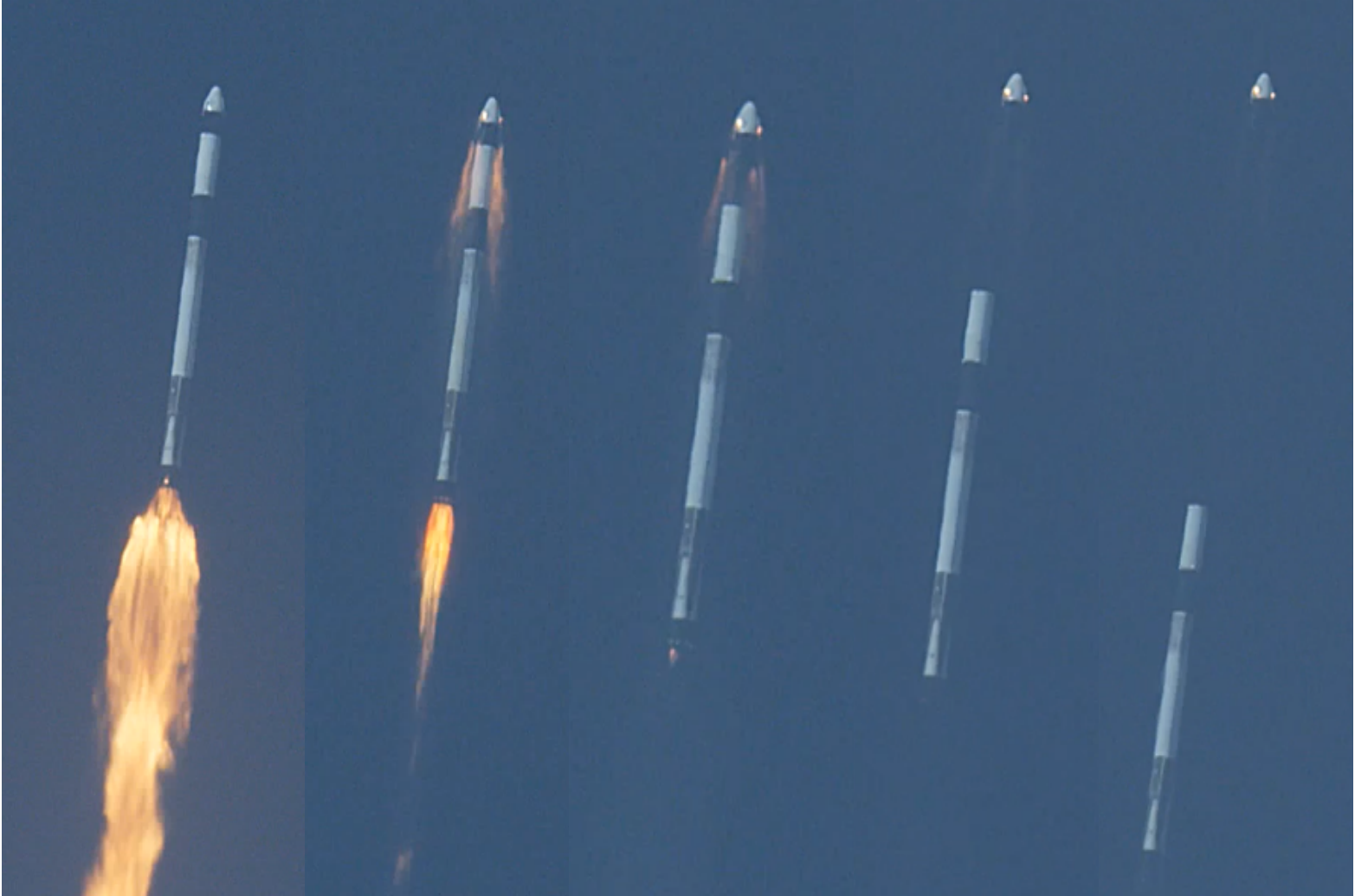


Draco-controlled Entry





# SpaceX In-Flight Abort Test





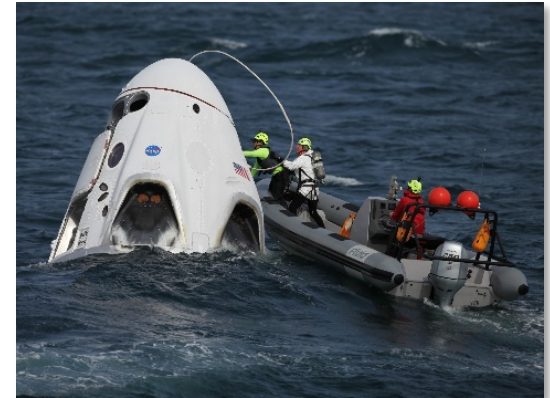


# SpaceX In-Flight Abort Test



- **Post-splashdown, DoD rescue forces simulated a crew rescue prior to capsule recovery**
- **Crew Dry Dress activity was performed two days prior to test, exercising complete NASA and SpaceX mission support teams anticipated for Demo-2 through crew prelaunch timeline**
- **Lessons learned from both Dry Dress and In-Flight Abort will be applied to Demo-2**

Rescue/Recovery Training



Crew Dry Dress, Demo-1 Crew at Dragon



Dragon with Crew Access Arm





# Demo-2 Mission Overview



- **First crewed flight of Docking Dragon vehicle**
  - First human launch from USA since STS-135
  - First human water landing since Apollo-Soyuz
- **Dragon Crew**
  - Doug Hurley (Spacecraft Commander)
  - Bob Behnken (Spacecraft Pilot)
- **Flight Plan: 30 days up to 119 days**
- **Flight Test Objectives**
  - Manual piloting tests planned
  - Other docked test objectives:
    - Emergency Safe Haven configuration
    - Emergency hardware stowage evaluation
    - Suit donning/doffing evaluations
    - Dragon habitability
  - Crew life support functionality
  - Crew control panel functionality
  - Parachute and thermal protection systems
  - Waste management system
  - Post landing rescue equipment demonstration and water recovery operations





# Boeing Crew Next Flight Test Status



- Although many of the objectives of Boeing's first uncrewed flight test were accomplished, Boeing has found the best approach to meeting the agency's requirements will be to fly a second uncrewed mission, including docking with the space station.
- NASA fully supports Boeing's commitment to flying our astronauts as safety as possible and we have accepted the proposal.
- The second uncrewed flight does not relieve Boeing from completing all the actions from the joint NASA/Boeing independent review team. NASA still intends to conduct the needed oversight to make sure those corrective actions are taken.
- NASA and Boeing are in the early stages of the decision to fly a second uncrewed mission, and a timeline for flying crew has not been determined.
- This illustrates the advantages of having two partners in CCP. Having dissimilar redundancy is key in NASA's approach to maintaining a crew and cargo aboard the space station. It also allows our industry partners to focus on crew safety rather than schedule.



# Program Cost Performance



- **Original CCP Budget from 2011 President's Budget Request**

(\$ in millions)	2011	2012	2013	2014	2015	Total
Commercial Crew Program	500	1,400	1,400	1,300	1,200	<b>5,800</b>

- **Actual expenditures (projected)**

- Total NASA investment in the development of both the SpaceX and Boeing crew transportation systems = **~\$5B**
- Total NASA cost for the entire development portion of CCP (all phases, all companies, plus NASA costs) = **~\$6B**

- **In 2009, a blue-ribbon committee known as the Augustine Committee was established to review the Constellation Program**

- Per NASA input, the Ares 1 and Orion (Block 1) were going to cost **\$24.5B**
- The Augustine Committee estimated that it would actually cost **\$34.5B**

**While not done yet, CCP is poised to save the Agency approximately \$20B-\$30B, and provide two, independent crew transportation systems.**





# CCP Contract Performance



- **Maximum Potential CCtCap Contract Value**
  - Boeing Original: \$4.229B      Boeing Current: \$4.368B (+3%)
  - SpaceX Original: \$2.599B      SpaceX Current: \$2.637B (+1.5%)
- **The CCtCap contracts are the largest fixed-price contracts for spacecraft development in the history of the Agency. It is notable that we are still within 5% of the contract baseline (although we are not done yet).**
- **Crewed Test Flight Dates (post-protest, established in January 2015)**
  - Boeing Original: July 2017      Boeing Current: TBD (XX-month slip)
  - SpaceX Original: April 2017      SpaceX Current: May 2020 (37-month slip)
- **NASA and our industry partners have consistently maintained that CCP is a safety-driven program, not a schedule-driven program.**
- **The first set of agreements (CCDev1) was established in 2010, but these were small awards for subsystems and technologies. The first “integrated system” set of awards were in August 2012 (CCiCap). Assuming we fly by mid-2020, the development timeline would be approximately 8 years.**





# Recent Developments



- **Space Adventures announced February 18 that it has an agreement with SpaceX to fly a dedicated Crew Dragon mission that would send four space tourists on a 5-day mission to a relatively high Earth orbit as early as 2021.**
- **Axiom Space announced on March 5 that it has an agreement with SpaceX to launch a team of three private astronauts and an Axiom-trained mission commander to the ISS for a 10-day mission as early as next year.**
- **This is the kind of outcome envisioned when we initiated CCP: enabling a new commercial market in which the U.S. companies provide services; and making NASA “one of many customers”.**
- **Initial seat prices will undoubtedly be high. However, prices for all major new transportation modes have started out high. Over time, as entrepreneurs enter the market and competitive forces take affect, prices come down.**
  - **Planes:** A non-stop, cross-country airline ticket in 1950 would have cost approximately \$1,400, in 2018 dollars. Today, a similar flight costs about \$400 – a **65% reduction**.
  - **Trains:** A train ticket purchased in 1830 would have cost about \$0.80 per mile, in 2018 dollars. A ticket purchased in 1940 would be about \$0.40 per mile – a **50% reduction**.
  - **Automobiles:** A new car in 1893 would have cost about \$106,700, in 2018 dollars. The average cost of a car in 2016 was about \$26,700 – a **75% reduction**.



# CCP Summary



- CCP continues to facilitate the development and certification of U.S. industry-based Crew Transportation Systems.
- Boeing and SpaceX are meeting contractual milestones and maturing their designs. NASA is engaged in meaningful insight.
- Both companies have completed multiple flight tests and are making tangible progress toward crewed missions to the International Space Station.



